IC 9022

Bureau of Mines Information Circular/1985

Field Trials of a Portable Microseismic Processor Recorder

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UNITED STATES DEPARTMENT OF THE INTERIOR

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BUREAU OF MINES
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Library of Congress Cataloging in Publication Data:

Coughlin, John P

Field trials of a portable microseismic processor recorder.

(Information circular / United States Department of the Interior, Bureau of Mines ; 9022)

Bibliography: p. 8.

Supt. of Docs. no.: I 28.27:9022.

1. Mine safety—Equipment and supplies—Testing. 2. Seismometers—Testing. I. Sines, Clinton D. II. Title. III. Series: Information circular (United States. Bureau of Mines) ; 9022.

TN295.U4   622s [622'.8]   84-23809

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ILLUSTRATIONS

UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

°F	degree Fahrenheit	ms	millisecond
ft	foot	pct	percent
h	hour		

FIELD TRIALS OF A PORTABLE MICROSEISMIC PROCESSOR RECORDER

By John P. Coughlin[1] ond Clinton D. Sines[2]

ABSTRACT

The Bureau of Mines has tested a portable microseismic processor recorder at the Galena Mine, Wallace, ID, both in an environmentally controlled enclosure and, with minimal protection, in a working area of the mine. In both trials the device demonstrated effective and reliable data acquisition capabilities.

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INTRODUCTION

The rate of microseismic activity in a mine is related to the ongoing development and relief of stress within the mine (3, 6-7).[3] Thus for some years the plotting and counting of located microseisms has provided a general idea of the relative stability of specific areas within a mine (1). Occasionally these techniques have identified an active area immediately prior to a rock burst (4).

The required techniques and the necessary hardware for collecting and evaluating microseismic data have been detailed elsewhere (1-2, 5, 8). A brief description of the detection and location of microseismic events follows: A transducer, which may be either a velocity gauge or an accelerometer, senses the ground motion caused by a microseismic event and outputs a voltage that varies with the amplitude and frequency of the motion. An electronic circuit detects and times the initial rise of this voltage above background noise. When several transducers detect the same microseism, the event arrival time at each transducer can be used to locate the event (1).

Fundamentally, microseismic monitoring in a mine consists of detecting ground motion, locating the associated microseisms, and plotting the locations or energy of the microseisms on mine maps. Other, more complex information in the microseismic waveform, such as the spectral energy distribution, could provide material for further analysis and perhaps enhance the ability of mine personnel to evaluate microseismic activity (9). For immediate needs, however, experience suggests that simple improvements in current techniques and equipment would contribute greatly to ongoing monitoring efforts. These improvements, which are described below, relate generally both to the reliability and accessibility of the microseismic data and to the ease with which mine personnel may install and operate the monitoring system.

This paper describes field trials of a portable microseismic processor recorder system (MPR) constructed by Science Applications, Inc., La Jolla, CA,[4] based on Bureau of Mines design recommendations.

GENERAL DESCRIPTION OF PORTABLE MPR

The portable MPR (fig. 1) provides the standard capabilities of an underground monitoring device such as a rock burst monitor (RBM) (1-2, 5) and in addition some new capabilities that enhance device utility. As a standard feature, the MPR measures the arrival time differences among voltage waveforms from a net of transducers responding to a microseismic event. These time differences, measured from the analogue inputs of 16 channels, are accurate to within 0.1 ms in a time window that adjusts from 1 to 200 ms. As a second standard feature, the MPR maintains the date in day of year and the time in hours, minutes, and seconds and provides these data in its output. The new and unique features of the portable MPR include the portability of the device, its mode of storing and providing data, its ability to distinguish mine drilling noise from real data, and its front panel display of event rates. These features are described in the following paragraphs.

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[3] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

[4] Reference to specific manufacturers does not imply endorsement by the Bureau of mines.

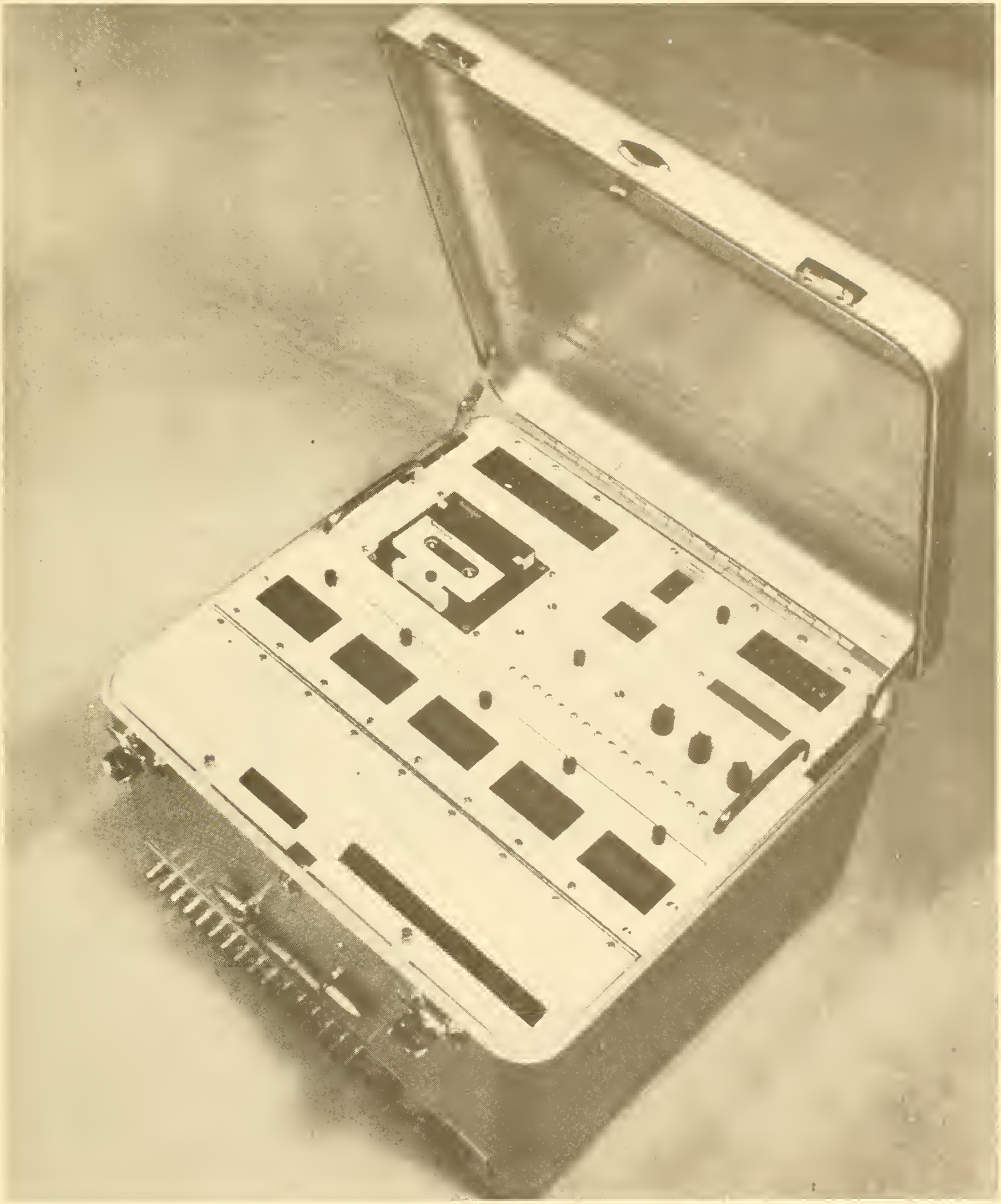

FIGURE 1. - The portable MPR. The five hit-count disploys are towards the battam of the instrument foce. Abave these are the anboard cassette recorder and time-af-day and naise suppression switches. On the outside of the case are the 16 water-resistant BNC connectors for analague input ond the waterpraof cannector for the computer interface.

EASE OF INSTALLATION AND PORTABILITY

The specific site at a mine where a monitoring device (MPR or RBM) is installed may influence both the quality of the acquired data and the flexibility of the monitoring system itself. The location may be either in the mine offices or within the mine itself. Installation of the system in the mine offices, even if they are underground, may require extra cable length, which may degrade the signal-to-noise ratio and add to maintenance problems. On the other hand, as has been the case with the fixed RBM systems at the Galena, installation underground in the mine itself may require construction of special enclosures complete with air conditioning and ac power.

These problems, which are inherent in choosing a fixed installation site, do not arise with the portable MPR, for with little or no extra environmental protection, the portable MPR will operate near the targeted working area of the mine. Essentially, all that is required is ac power, and should this power be interrupted, the MPR will maintain the data displays and the time of day clock for up to 72 h.

DATA STORAGE AND COMPUTER LINK

The portable MPR provides data to a host computer through a standard RS-232 interface (fixed at 9,600 baud); alternately, the MPR will run without a host computer and store data in an onboard cassette. Commmunication between the MPR and the computer is two-way and may be initiated by either the computer or the MPR. In the former case, the computer commands the MPR to transmit a block of data for each event stored in internal memory. In the latter case, the MPR requests permission to begin sending data. If permission is not granted, the MPR returns to logging in data and stores the data in a circular buffer with a 50-event capacity.

In the case of operation without a host computer, the MPR simply stores the event data on cassette tape. Mine personnel may retrieve the cassette and obtain the stored data through a cassette reader, which outputs either directly to a printer or to a computer.

Thus the portable MPR logs in data for computer analysis whether or not a computer is immediately available.

SUPPRESSION OF MINE DRILLING NOISE

Background mining noise such as drilling may overload a monitoring system with meaningless seismic data and possibly prevent detection of both ordinary microseismic events and rock bursts. Certain software techniques can filter out some drilling noise (5), but these techniques require a host computer.

The portable MPR addresses this problem without the aid of a host computer. Through a system of automatic gain control, the portable MPR distinguishes drilling from other seismic events and eliminates it from further processing. Since each channel independently screens out drilling noise, one or two overly active channels will not cause the MPR to suppress genuine microseismic data.

TOP PANEL DATA DISPLAY

The portable MPR maintains five displays on an inside top panel (fig. 1). Four of these displays count the number of times a particular geophone has triggered since the last counter reset; the fifth display represents the total number of events logged since it was last reset. Mine personnel, knowing where each

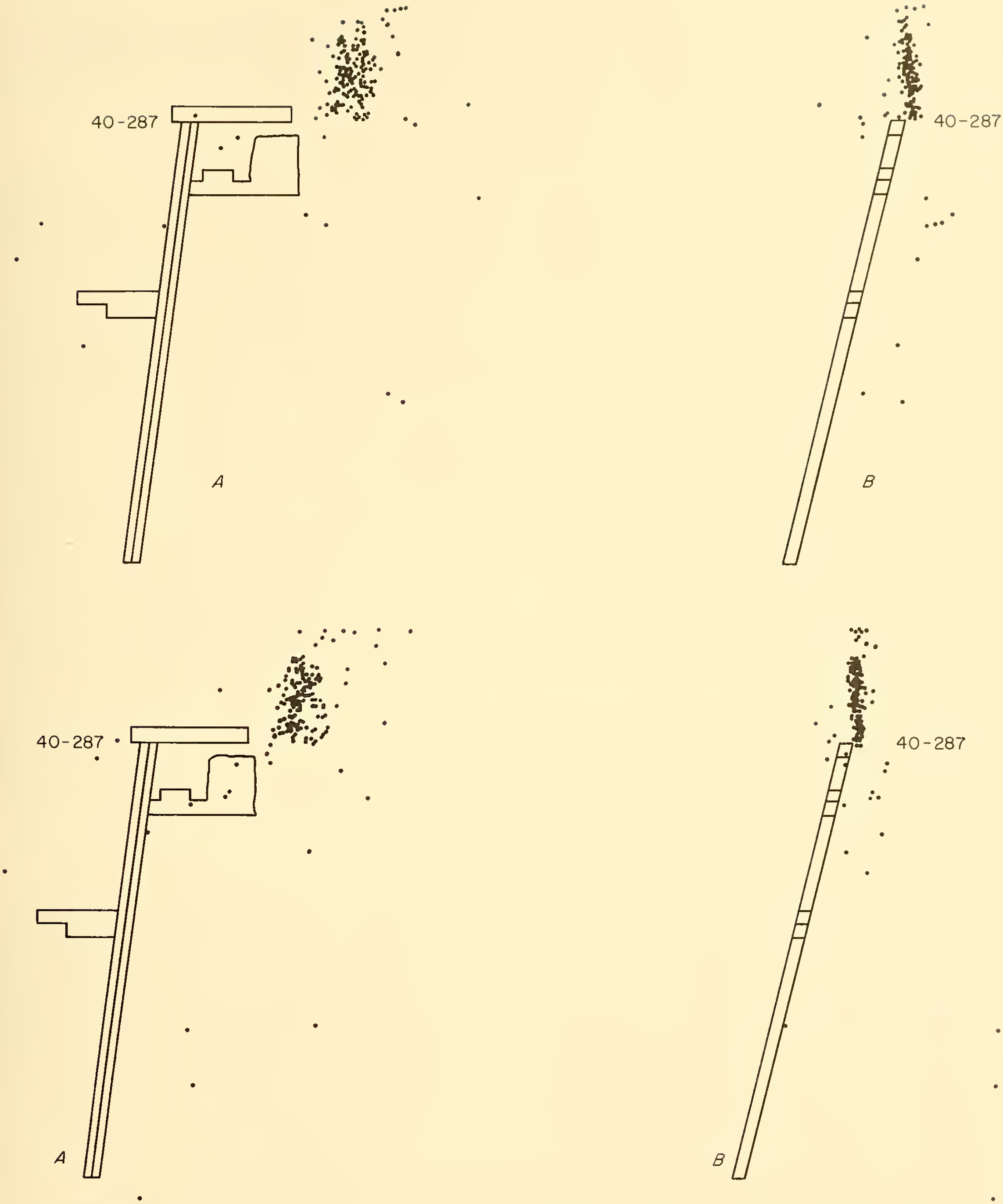

FIGURE 2. - Comparison of events detected with fixed RBM (top) and portable MPR (bottom). The events were triggered by drilling and bolting in the stope back. Projection A is a side view, and projection B is an end view.

geophone is located, may use these display units to get an idea of the spatial distribution and intensity of microseismic events in a given time interval. Thus the MPR itself, without additional peripherals, provides mine personnel with an immediate and useful, though rough, summary of microseismic activity throughout the monitored area.

MPR TRIAL RUNS

The trial runs of the portable MPR at the Galena Mine tested not only for the reliability and accuracy of the MPR data but also for the capacity of the MPR to operate with minimal protection in a mining environment. In the first of two sets of trial runs, the portable MPR monitored the Galena East end in parallel with the well-tested Denver Research Center (DRC) fixed RBM system (5). In the second set of trial runs, the portable MPR independently monitored a stope, 46-99, that had suddenly begun showing intense audible activity.

MONITORING IN PARALLEL WITH FIXED RBM SYSTEM

Figure 2 shows one day of microseismic activity recorded on the DRC fixed RBM system at the Galena's 40-287 stope. These events were triggered by bolting and drilling for a 6-ft backstope round.

Figure 2 also shows the same activity as recorded on the portable MPR. The broad features of the two plots are the same, but the portable MPR counted more events in the same time than did the fixed RBM. This count surplus is related to the differing storage capacities of the two devices. The portable MPR, if the host computer or the onboard cassette is currently occupied, stores up to 50 events in onboard memory. On the other hand, the fixed RBM has only single-event storage capability and must pass this data on to a host computer before continuing with data acquisition. (The capacity of the fixed RBM system is

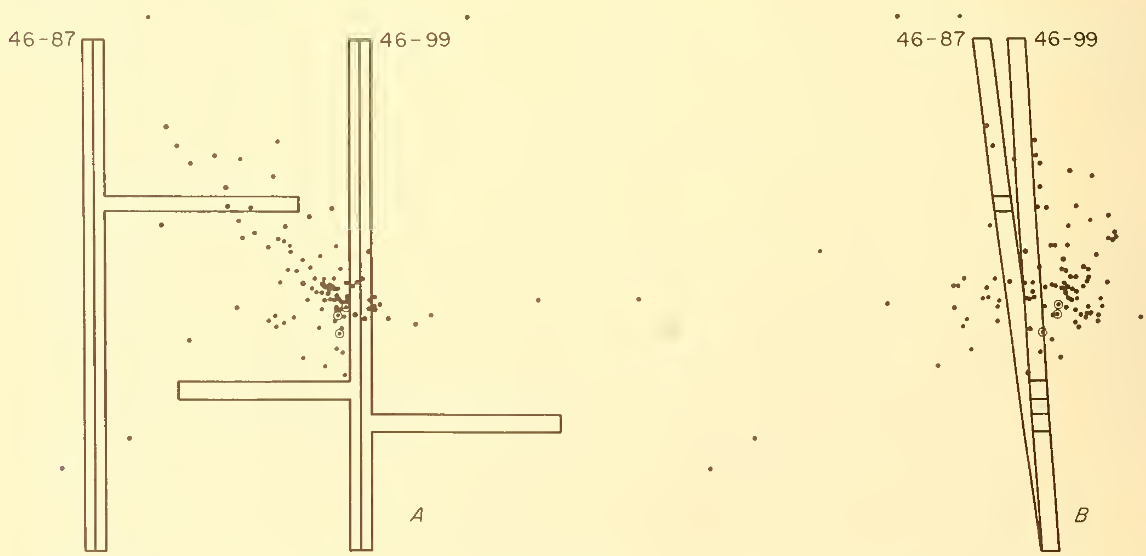

FIGURE 3. - Location of events recorded on MPR over a 1-day period. The three circled events are of relatively large size and include a small rock burst. Most of the events in the plot followed the burst. Projection *A* is a side view and projection *B* is an end view of a two-stope system.

thus a function of the programming within the host computer, and in this instance the programming is such that the fixed RBM system has slightly less capacity.)

INDEPENDENT MONITORING

Figure 3 is a plot of 1 day's portable MPR data in 46-99 stope. The three circled events in this plot were identified as relatively large by a software routine that checks for triggering in a unique low-gain-system channel (5). The largest of these three events was a rock burst that registered on a seismograph on the surface some 6,000 ft away. Most of the other events in the plot followed this burst.

The emplacement of the portable MPR at 46-99 stope (fig. 3) was part of a prompt response to a sudden increase in activity around the stope. In 16 work hours, a seven-phone network was on-line collecting data. The portable MPR together with a set of variable-gain amplifiers and an oscilloscope was installed in a wooden box some 300 ft from 46-99 raise. The temperature outside the box was 90° F, and the humidity was 94° pct.

Figure 4 is a plot of total activity in the stope over a 30-day period. In all, the equipment successfully logged in data for 60 days, until the low grade of mined ore and bursting problems dictated a stope shutdown.

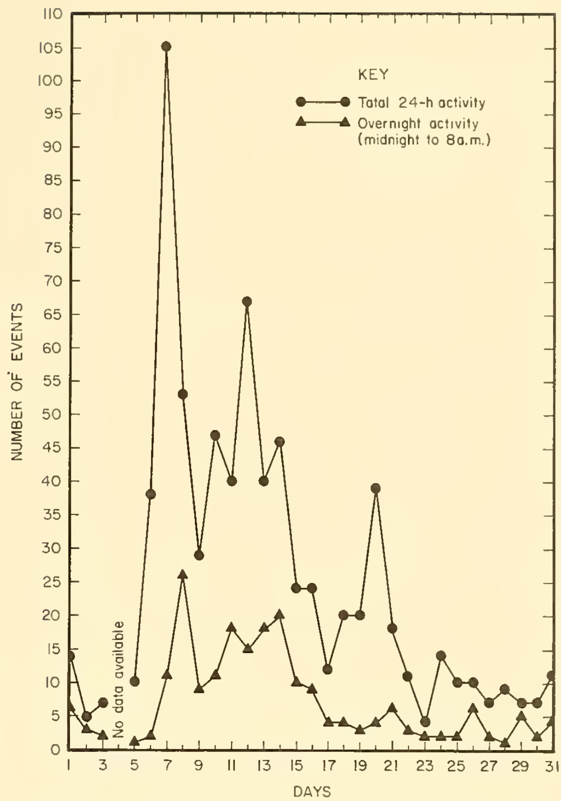

FIGURE 4. - Daily plot of events recorded on MPR over a 1-month period. Small rock bursts occurred on days 7, 19, and 20. On day 7 most of the detected activity followed the burst.

CONCLUSIONS

In tests at a working mine, the portable MPR has demonstrated the ability to provide accurate and useful data. The MPR enabled a swift response to an apparently increasing stress system around a stope and operated without failure in close proximity to the stope. Moreover, for some months after these tests, the MPR successfully operated as part of a routine monitoring system. Thus the portable MPR is demonstrably an effective and reliable tool for industry use in underground monitoring.

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